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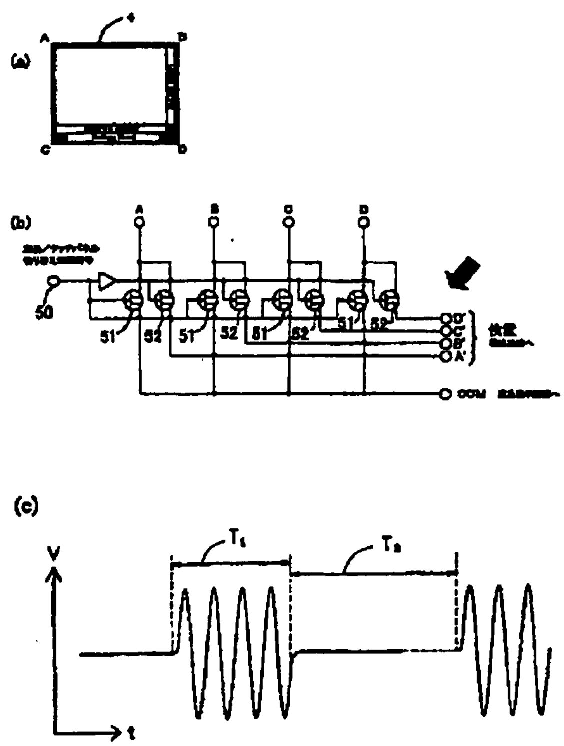
(54) **[Title of the invention]** Display device being integrated with touch sensor

57) **[Summary]**

[Objective] To provide display devices being integrated with a touch sensor without causing loss of display quality.

[Means to solve] It is a display device being equipped with an active matrix substrate 4 having multiple pixel electrodes that are laid out on the first surface in a matrix shape, and a transparent opposing electrode that opposes the first surface of the active matrix substrate 4, and further being equipped with, a liquid crystal display circuit that supplies voltage or electric current for display to transparent opposing electrode, a position detection circuit that detects electric current that runs from multiple locations of said transparent opposing electrode, and a switching circuit that electrically connects either one of these circuits with a transparent common electrode.



[Patent claims]

[Claim 1] Display device, which is a display device being equipped with an active matrix substrate having multiple pixel electrodes that are laid out on the first surface in a matrix shape, and a transparent opposing electrode that opposes the first surface of said active matrix substrate,
and further being equipped with,
the first circuit that supplies voltage or electric current for display to transparent opposing electrode,
the second circuit that detects electric current that runs from multiple locations of said transparent opposing electrode,
and a switching circuit that electrically connects either one of said first circuit and second circuit with said transparent electrodes.

[Claim 2] Display device being described in Claim 1 wherein said switching circuit periodically switches electrical connection between said first circuit or second circuit and said transparent common electrode, corresponding to a control signal.

[Claim 3] Display device being described in Claim 1 or 2 wherein each of at least a part of said first circuit, at least a part of said second circuit, and said switching circuit, has thin film transistors that are formed on said active matrix substrate.

[Claim 4] Display device being described in Claim 3 wherein said thin film transistors have multi-crystalline silicon that is deposited on said active matrix substrate.

[Claim 5] Display device being described in Claim 3 or 4 wherein said transparent opposing electrode has multiple divided regions and electric current that runs both ends of each of said multiple regions is detected with said the second circuit.

[Claim 6] Display device which is described in one of Claims 1 through 5, and has a liquid crystal layer being provided between said multiple pixel electrodes and said transparent opposing electrode.

[Claim 7] Display device being described in Claim 6 wherein said transparent opposing electrode is formed on other substrate that opposes said substrate and said liquid crystal layer is sealed between the both substrate.

[Claim 8] Display device which is described in one of Claim 1 through 5, and has an organic EL layer being provided between said multiple pixel electrodes and said transparent opposing electrode.

[Claim 9] Display device, which is a display device being equipped with a first substrate having multiple scanning electrodes that are laid out on the first surface, and a second substrate having multiple data electrodes that oppose said the first surface of the first substrate,
and further being equipped with,
the first circuit that supplies voltage or electric current for display to each data electrode,
the second circuit that detects electric current that runs from multiple locations of each data electrode,
and a switching circuit that electrically connects either one of said first circuit and second circuit with said data electrodes.

[Claim 10] Display device, which is a display device being equipped with a first substrate having multiple first electrodes that are laid out on the first surface, and a second substrate having multiple second electrodes that oppose said first surface of the first substrate,
and further being equipped with,
a first circuit that supplies voltage or electric current for display to each first electrode,
a second circuit that detects electric current that runs from multiple locations of each first electrode,
and a switching circuit that electrically connects either one of said first circuit and second circuit with said first electrodes.

[Claim 11] Display device being described in Claim 9 or 10 wherein at least a part of said first circuit, at least a part of said second circuit, and said switching circuit, have thin

film transistors that are formed on said substrate.

[Claim 12] Display device being described in Claim 11 wherein said thin film transistors have multi-crystalline silicon that is deposited on said substrate.

[Claim 13] Display device which is described in one of Claim 9 through 12, and has a liquid crystal layer being provided between said first substrate and said second substrate.

[Claim 14] Display device, which is a display device being equipped with,
a display media having a display surface that expands two dimensionally,
a drive means that forms electric field to selected region of said display media,
and a position detection means that detects contact point from outside within a surface that is parallel to said display surface with electrostatic capacitance coupling method;
wherein said driving means has transparent electrodes,
and said position detection means is electrically connected with multiple portions of said transparent electrodes and detects electric current that corresponds said contact point.

[Detail description of the invention]

[0001]

[Technology field this invention concerns]
This invention concerns display devices which are able to detect contact position of pen and finger tip at the display surface, and it is applied for liquid crystal display devices and organic EL devices.

[0002]

[Prior technology] Touch sensor or touch panel are input devices for position detection of location where contact occurs with such as a finger or pen. As the method for position detection, such as electrostatic capacitance coupling method, resister film method, infrared method, ultrasonic sound method, and electromagnetic induction/coupling method have been known.

[0003] According to the "resister film method" that has been widely adopted, detection of position is done by placing two transparent resister films opposing each other and utilizing contact of resister films each other at a position where contacted with such as a pen.

[0004] When using these touch panels as integrated with a display, a touch panel will be placed in front of image display part of such as liquid crystal display panel, for example. In the case of a touch panel in resister film method, for example, the integration is accomplished by first laminating two sheets of transparent resister film with adhesive to make a resister sheet, then by adhering this resister film on front surface of an image display device with adhesive. Further, a basic device of a touch panel according to electro-static capacity coupling method is disclosed in public notice of Patent Publication Shou 56-500230.

[0005]

[Problems that the invention is to solve]
For the use of previous touch sensor being integrated with an image display device, the touch panel was laid over the surface of a display device. In this case, there have been a problem that transmission rate of light from the display device is reduced due to the existence of the touch panel on the display surface and display quality is degraded. For example, in the case of resister film type touch panel, transmission rate of light was especially poor due to existence of air which has different refractive index between two sheets of resister film.

[0006] Further, there also have been a problem that thickness and weight of entire device will increase by the addition of a touch panel.

[0007] This invention was done considering above descried situations and it major objective is to provide display devices being integrated with a touch sensor that is light weight and suitable for miniaturization without causing degradation of display

performance.

[0008]

[Means to solve the problems] The display device of this invention is a display device being equipped with an active matrix substrate having multiple pixel electrodes that are laid out on the first surface in a matrix shape, and a transparent opposing electrode that opposes the first surface of said active matrix substrate; and further being equipped with, the first circuit that supplies voltage or electric current for display to transparent opposing electrode, the second circuit that detects electric current that runs from multiple locations of said transparent opposing electrode, and a switching circuit that electrically connects either one of said first circuit and second circuit with said transparent electrodes.

[0009] In a desirable embodiment form, said switching circuit periodically switches electrical connection between said first circuit or second circuit and said transparent common electrode, corresponding the control signal.

[0010] In a desirable embodiment form, at least one part of said first circuit, at least one part of said second circuit and said switching circuit have thin film transistors which are formed on said substrate.

[0011] In a desirable embodiment form, said thin film transistors have multi-crystalline silicone that is deposited on said substrate.

[0012] In a desirable embodiment form, said transparent opposing electrode has divided multiple regions and electric current that flows both ends of each of said multiple regions is detected by said second circuit.

[0013] In a desirable embodiment form, it has a liquid crystal layer that is provided between said multiple pixel electrodes and said transparent opposing electrodes.

[0014] In a desirable embodiment form, said transparent opposing electrode is formed on other substrate that opposes said substrate, and said liquid crystal layer is enclosed between both substrates.

[0015] In a desirable embodiment form, it has an organic EL layer that is provided between said multiple pixel electrodes and said transparent opposing electrodes.

[0016] The display device of this invention is a display device being equipped with a first substrate having multiple scanning electrodes that are laid out on the first surface, and a second substrate having multiple data electrodes that oppose said the first surface of the first substrate, and further being equipped with, the first circuit that supplies voltage or electric current for display to each data electrode, the second circuit that detects electric current that runs from multiple locations of each data electrode, and a switching circuit that electrically connects either one of said first circuit and second circuit with said data electrodes.

[0017] The display device of this invention is a display device being equipped with a first substrate having multiple first electrodes that are laid out on the first surface, and second substrate having multiple second electrodes that oppose said first surface of the first substrate, and further being equipped with, a first circuit that supplies voltage or electric current for display to each first electrode; a second circuit that detects electric current that runs from multiple locations of each first electrode, and a switching circuit that electrically connects either one of said first circuit and second circuit with said first electrodes.

[0018] In a desirable embodiment form, at least one part of said first circuit, at least one part of said second circuit and said switching circuit have thin film transistors which are formed on said substrate.

[0019] In a desirable embodiment form, said thin film transistors have multi-crystalline silicone that is deposited on said substrate.

[0020] In a desirable embodiment form, it has a liquid crystal layer that is provided between said first substrate and said second

substrate.

[0021] The display device of this invention is a display device being equipped with, a display media having a display surface that expands two dimensionally, a drive means that forms electric field to selected region of said display media, and a position detection means that detects contact point from outside within a surface that is parallel to said display surface with electrostatic capacitance coupling method, and wherein said driving means has transparent electrodes, and said position detection means is electrically connected with multiple portions of said transparent electrodes and detects electric current that corresponds said contact point.

[0022]

[Form of embodiment of the invention]

In the following, forms of embodiment of the display device according to this invention are described referring to illustrations.

[0023] At first, Figure 1 is referred. Figure 1 schematically shows a constitution when this invention is applied for a liquid crystal display device. In the illustration, back light 1, diffuser sheet 2, first polarizer sheet 3, substrate (the first substrate) 4, TFT array 5, liquid crystal layer 6, opposing conductive film 7, color filter 8, opposing substrate (the second substrate) 9, and the second polarizer sheet 10 are laminated in this order from the bottom.

[0024] In the following, the constitution of a liquid crystal display device in this form of embodiment is more concretely described.

[0025] On the first surface of a substrate 4 that is formed with transparent insulation material such as glass or plastics, a TFT array is formed and pixel electrodes (not shown in the drawing) are laid out in matrix shape. Because the pixel electrodes are driven by active matrix system, the substrate 4 in a condition being formed with such as TFT array 5 is called "active matrix substrate" in this document.

[0026] The TFT array on the substrate 4 is those wherein thin film transistors (TFT) are laid out which have semiconductor layers of such as amorphous silicone and multi-crystalline silicone. Actual substrate 4 has extended area beyond peripheries of display region and a driver circuit (gate driver and source driver) for driving the pixel TFT within the display region and for supplying desired amount of electric charge to the pixel electrodes are formed in that region. In a desirable form, transistors that compose the driver circuit are formed with similar TFTs with the transistors which compose the TFT array within the display region. In this case, it is desirable to compose the driver circuit and TFT array by using multi-crystalline silicone film, in order to increase operational speed of the driver circuit. In order to increase the operational speed of the TFT as much as possible, it is desirable to lower the barrier whic is felt by a carrier when it crosses a grain boundary in the milti-crystalline silicone film and to make TFTs by using CGS (continuous grain boundary silicone) film.

[0027] Where, the TFTs for pixels which compose the TFT array are connected to the driver circuit through wiring (gate wiring and data wiring) in the following schematic. Also, a protection layer and an orientation layer which are not shown in the illustration are provided to cover the TFT array on the active matrix substrate.

[0028] A color filter 8 and an opposing electro-conductive film 7 that is formed with a transparent electro-conductive film (ITO for example) are formed in this order on the side of liquid crystal of substrate 9 that opposes the active matrix substrate.

[0029] Desired voltage is applied to each portion of a liquid crystal layer that is located between the active matrix substrate and the opposing substrate 9 by the opposing electro-conductive film 7 and pixel electrode that is not shown in the illustration. With this application of voltage, direction of the liquid crystal molecule changes and it is able to

modulate the light comes out from the back light 1.

[0030] The basic constitution that is shown in Figure 1 is those that have been widely used for conventional liquid crystal display. In this invention, the opposing electro-conductive film 7 in Figure 1 is not only used as a common electrode for display but also used as an electro-conductive film for position detection (transparent resister film).

[0031] As described above, in the case of adding an electro-conductive film for position detection to a conventional liquid crystal display device, not only the display quality is degraded but also there is a problem that signal for liquid crystal display functions as noise to the signal for position detection. Accordingly, there are cases that an insulation layer is necessary for noise reduction between a polarizer film 10 and the position detection layer and further worsen the degradation of display quality. However with this form of embodiment, above described problems of degradation of display quality is able to be solved because time period when the opposing electro-conductive film 7 is used as a common electrode for display and time period when it is used as an electro-conductive film for position detection are separated in time and alternatively switched.

[0032] Electrodes for position detection are formed on four corners of the opposing electro-conductive film 7 being used in this form of embodiment. These electrodes are applied with AC voltage and an electric field with little gradient is almost uniformly generated in the opposing electro-conductive film 7.

[0033] When surface of the polarizer sheet 10 or other insulation material that is formed over it is contacted with a pen or finger, the opposing electro-conductive film 7 is coupled with the ground in capacitance. This capacitance is the total of the capacitance between the polarized film 10 and the opposing electro-conductive film 7, and the capacitance that exists between a person and the earth.

[0034] Electric resistance between contacted point being capacitance coupled and each of electrodes on the opposing electro-conductive film 7 is proportional to the distance between the contact point and each electrode. Therefore, electric current that is proportional to the distance between the contact point and each electrode will run through the electrode on four corners of the opposing electro-conductive film 7. By detecting the amount of these electric current, it is able to obtain position coordinate of the contacted location.

[0035] In the following, an explanation is made on the basic principle of the position detection method by electrostatic capacitance coupling method that is used in this invention by referring to Figure 2.

[0036] In Figure 2, one dimensional resister that is placed between an electrode A and an electrode B is shown in order to simplify the explanation. In an actual display device, an opposing electro-conductive film having two dimensional expansion performs similar function with this one dimensional resistor.

[0037] Each of the electrode A and electrode B, are connected with resistors r, which are for conversion of electric current to voltage. The electrodes A and B are connected to a position detection circuit through a switching circuit which are described later. In this form of embodiment, these circuits are formed in an active matrix substrate in this form of embodiment.

[0038] In position detection mode, the same phase and the same potential of voltage (alternating current e) is applied between the electrode A and ground and the electrode B and ground. In this case, there is no electric current running between the electrode A and the electrode B because the electrode A and the electrode B are always at the same electric potential.

[0039] Then position C is touched with such as a finger. Where, resistance from the

contact point C by a finger to the electrode A is defined as R_1, resistance from the contact point C to the electrode is defined as R_2 and $R = R_1+R_2$. If impedance of a person is defined as Z, electric current that runs through the electrode A is defined as i_1 and electric current that runs through the electrode B is defined as i_2, following equations apply.

[0040]

$$e = ri_1 + R_1i_1 + (i_1 + i_2)Z \qquad \text{(Equation 1)}$$
$$e = ri_2 + R_2i_1 + (i_1 + i_2)Z \qquad \text{(Equation 2)}$$

[0041] From above described Equation 1 and Equation 2, following Equation 3 and Equation 4 are obtained.

[0042]

$$i_1(r+R_1) = i_2\,(r+R_2) \qquad \text{(Equation 3)}$$
$$i_2 = i_1(r+R_1) / (r+R_2) \qquad \text{(Equation 4)}$$

[0043] By substituting Equation 1 with Equation 1, following Equation 5 is obtained.

[0044]

$$e = ri_1 + R_1i_1 + (i_1 + i_2(r+R_1) / (r+R_2))Z$$
$$= i_1(R(Z+r) + R_1R_2 + 2Zr + r^2) / (r+R_2) \qquad \text{(Equation 5)}$$

[0045] From above Equation 5, following Equation 6 is obtained.

[0046]

$$i_1 = e(r+R_2) / R(Z+r) + R_1R_2 + 2Zr + r^2) \qquad \text{(Equation 6)}$$

[0047] Equation 7 is obtained similarly.

[0048]

$$i_1 = e(r+R_1) / R(Z+r) + R_1R_2 + 2Zr + r^2) \qquad \text{(Equation 7)}$$

[0049] When ratio of R_1 and R_2 is shown by using total resistance R, Equation (8) is obtained.

[0050]

$$R_1/R = (2r / R+1)i_2 / (i_1+i_2) - r/R \qquad \text{(Equation 8)}$$

[0051] Because r and R are already known, R_1/R is able to be determined with Equation 8 by obtaining electric current i_1 running through electrode A and electric current i_2 running through electrode B by a measurement. Where, R_1/R is not dependent on impedance Z that includes a human that touches with a finger. Therefore, Equation 8 is valid as long as the impedance Z is not zero or infinitive, and it is able to ignore variation or condition by person or material.

[0052] In the following, an explanation is made on the case when above described one dimensional case is expanded to two dimensional case, by referring to Figure 3 and Figure 4. Where, four electrodes A, B, C and D are formed on four corners of opposing electro-conductive film 7 as shown in Figure 3. These electrodes A through D are connected to a position detection circuit through a switching circuit on the active matrix substrate.

[0053] Refer to Figure 4. As shown in Figure 4, the same level and the same phase of AC voltages are applied to the electrodes on the opposing electro-conductive film, and electric current which run through four corners of opposing electro-conductive film 7 by contact of such as a finger is defined as i_1, i_2, i_3 and i_4, respectively. In this case, following equations are obtained by similar calculation with above described calculation.

[0054]

$$X = K_1+K_2 \cdot (i_2+i_3) / (i_1+i_2+i_3+i_4) \qquad \text{(Equation 9)}$$
$$Y = K_1+K_2 \cdot (i_1+i_2) / (i_1+i_2+i_3+i_4) \qquad \text{(Equation 10)}$$

[0055] Where, X is X coordinate of contact point on the opposing electro-conductive film, and Y is Y coordinate of contact point on the opposing electro-conductive film. Further, k_1 is offset, k_2 is magnification ratio. k_1 and k_2 are constants that does not depend on impedance of human.

[0056] According to above described Equation 9 and Equation 10, it is able to determine contacted position by measurement values of i_1 through i_4 which runs through four electrodes.

[0057] Although contacted point on a surface having two dimensional expansion is detected by locating electrodes at four corners of the opposing electro-conductive film 7 in above example, quantity of electrodes on the

opposing electro-conductive film is not restricted in four. Minimum quantity of electrodes which is needed for detecting two dimensional position detection is three, however, it is able to increase accuracy of position detection by increasing the quantity of electrodes to five or more. Relation of the quantity of electrodes and position detection accuracy is later described in detail.

[0058] In order to determine coordinates of contacted point following above described principle, it is necessary to measure values of electric current running through multiple electrodes being located on the opposing electro-conductive film 7. Also, in display mode, the opposing electro-conductive film 7 is required to apply specific voltage that is needed to display, on liquid crystal layer 6.

[0059] Therefore, a switching circuit is located along with the drive circuit on the active matrix substrate where the TFT array is formed, as shown in Figure 5(a), in this form of embodiment. While opposing electro-conductive film 6 and electrode A through D are formed on an opposing substrate that is not shown in the drawing, electro-conductive members (they are shown in A through D in the drawing) that are to be connected with the electrodes A through D are located on the active matrix substrate. These electro-conductive members are electrically connected with the electrodes A through D on the opposing substrate. This connection is done as same as the connection that has been done between opposing electro-conductive film on opposing substrate and display circuit on active matrix substrate in previous display devices.

[0060] Figure 5(b) is a circuit schematic showing composition example of a switching circuit. The signal for controlling change over of switching circuit is applied to terminal 50. This control signal is generated by a control circuit that is not shown in the drawing. When the control signal is at "High" level, the first transistor 51 in the switching circuit is in conductive state and transistor 52 is in non-conductive state. At this moment, the electrodes A through D are electrically connected with a common electrode (COM) of the liquid crystal display circuit and receives application of voltage that is needed for the display.

[0061] On the other hand when the control signal transits from "High" level to "Low" level, the transistor 51 in the switching circuit changes to non-conductive state and the transistor 52 turns to conductive state. As a result, the electrodes A, B, C and D are electrically connected to terminals A', B', C' and D' of the position detection circuit, respectively. And above described measurement of electric current i_1 through i_4 and determination of position coordinate are executed.

[0062] Figure 5(c) is a graph showing the change of electric potential of the opposing electro-conductive film 7 with time. Vertical axis shows electrical potential of opposing electro-conductive film 7 and horizontal axis shows time. With the switching circuit, position detection mode (time period T_1) and display mode (time period T_2) are alternatively and periodically switched. In the display mode, four corners of the opposing electro-conductive film 7 are all electrically short circuited and electrical potential that is necessary for driving liquid crystal (common voltage (COM) is assigned to the opposing electro-conductive film 7. On the other hand in the position detection mode, the electrodes A through D on the four corners of the opposing electro-conductive film 7 are connected to the position detection circuit by the switching circuit that is constituted with transistors and diodes.

[0063] According to a normal constitution of liquid crystal display device, it is desirable to set time period T_1 of the position detection mode at 0.2 msec. or longer. Also, because position detection is done in a sampling cycle of (T_1+T_2), if the time period (T_1+T_2) is too

long, it causes a problem that when the contact point with a finger or pen is quickly moved on a display surface, the spacing between position coordinates which are supposed to be continuously detected along with the move of contact points gets wide open. In order to avoid this kind of problems, it is desirable to set T_1+T_2 to be 17 msec. or less.

[0064] Further, frequency of AC voltage that is applied to the opposing electro-conductive film 7 in the position detection mode is set within a range of 30 to 200 kHz, and amplitude of voltage is set within a range of 2 to 3 volts for example. DC bias voltage of 1 to 2 volts may be added to this AC voltage. Further, the common voltage for display does not have to be fixed at a constant value and for example, polarity may be reversed by each field of display.

[0065] Also, however it is not shown in Figure 5(a), transistors that composes the position detection circuit is also desired to be formed on the active matrix substrate 4 as same as the transistors that constitutes the drive circuit or the switching circuit. Because if each circuit is integrated on the same substrate, deformation of wave shape is less prone to cause and degradation of image quality due to the switching operation is less prone to occur.

[0066] In the following, the constitution of the position detection circuit is described by referring to Figure 6.

[0067] The position detection circuit being shown in the illustration has four electric current change detection circuits 61. The electric current change detection circuits 61 measure electric current that run between each of the electrodes A through D of the opposing electro-conductive film and ground in position detection mode. AC voltage is applied to each of electrodes A through D with a touch sensor AC drive oscillation circuit 65. Therefore, the electric current that runs each of the electrodes A through D by contact with such a finger has AC component. Output from the electric current change detection circuit 61 receives amplification processing and band pass filtering with an analog signal processing circuit 62. Output of the analog signal processing circuit 62 is detected with a detection filtering circuit 63, then further entered into a noise elimination and DC conversion circuit 64. The noise elimination and DC conversion circuit 64 converts the output from the detection filtering circuit 63 to DC and signals are generated that have proportional values to the electric current that run the electrodes A through D.

[0068] The analog multiplexer 66 that receives said signals from the noise elimination and DC conversion circuit 64 sends out the output from the electrodes A through D in this order to an A/D converter 67, after switching said signals. The A/D converter 67 sends digitized signal (data) to a processing unit 68. The processing unit 68 is the unit that is mounted in portable information terminals (PDA) for example, or in various computers and executes data processing.

[0069] It is not necessary that everything of various circuits that are included in above position detection circuit is formed on the active matrix substrate, however, at least the circuit of Figure 5(b) that includes transistors 51 and 52 is desired to be formed on the active matrix substrate along with other TFT array.

[0070] With the display device of integrated touch sensor type according to this invention, there is no need to separately prepare a touch sensor which is provided with position detection electrically conductive film on a substrate of such as glass and mount the touch sensor over the image display surface of an image display device, because the opposing electro-conductive film which is a composing component of the display device is also a position detection electro-conductive film.

Accordingly, previous problem that image display quality such as transmission rate and reflectance is degraded for the substrate of touch sensor, is solved.

[0071] However according to this invention, the distance between contacted point with a finger or pen and the electro-conductive film tends to be longer than the distance with previous ones, because an electro-conductive film that is located at inside region of the two substrate is used for position detection. There is a tendency that if this distance gets long, sensitivity of position detection gets less. In order to avoid this reduction of sensitivity, it is desirable to make the thickness of opposing substrate thinner. Desirable thickness of opposing substrate is 0.4 to 0.7 mm.

[0072] Further, locations where placing the position detection electrodes in the display device of this invention are not restricted at the four corners of opposing electro-conductive film. As shown in Figure 7, other electrodes E, F, G and H may be provided in the middle of the electrodes A and B or in the middle of electrodes C and D. By installing many electrodes as this, it is able to improve position detection accuracy by doing position detection with electrodes C, D and E immediately after the position detection with three electrodes A, B and F, for example.

[0073] Further it is desirable to provide multiple split electrodes O_1-O_{nx}, P_1-P_{nx}, Q_1-Q_{ny} and S_1-S_{ny} (nx and ny are both natural number of 2 or greater) between the electrodes at four corners as shown in Figure 8. An electrode Oj (j is $1 \leq j \leq nx$) that is included in the split electrodes O_1-O_{nx} being located between the electrodes A and B, is made to correspond an electrode Pj that is included in the split electrodes P_1-P_{nx} being located between the electrodes C and D. And while scanning j from 1 through nx in sequence, electric current that run through each of corresponding electrodes Oj and Pj. By doing this, XY coordinate of the contact point is able to be determined in high accuracy. Number of electrodes that are formed on one edge of the opposing electro-conductive film 7 may be set at 4 through 10, for example.

[0074] According to the electro-static capacitance coupling method that is chosen by this invention, there is a case that some error occurs between actual contact position and calculated contact position from the amount of electric currents that run through electrodes on the four corners of the opposing electro-conductive film. However, if value of electric current that run through each electrode is measured by scanning large quantity of electrodes which are provided at above described multiple locations, it is able to realize detection of very high accuracy.

[0075] When number of electrodes thus increases, complexity of mutual connections of drive circuit, position detection circuit and switching circuit increases exponentially. However, if the switching elements and the position detection circuit are built in the same substrate with the driver circuit, there is no need to mutually connect each circuit with long wires with providing a large quantity of terminals. As a result, it is able to prevent degradation of image quality due to signal retardation.

[0076] The opposing electro-conductive film 7 is composed with single layer of transparent electro-conductive film, in the form of embodiment that has been described in above. However, the opposing electro-conductive film of this invention is not restricted within those which comprises one piece of continuous film. For example, the opposing electro-conductive film 7 may be divided in multiple sections 7_1 through 7_N as shown in Figure 9. In this case, one pair of electrodes are formed on each of divided sections 7_1 through 7_N. By adopting this constitution, a condition that multiple units of one dimensional resister of Figure 2 are aligned. In this case, position detection regarding Y coordinate is determined by the amount of

electric current that runs through a pair of electrodes that are provided on each divided section. On the other hand, detection of position in X coordinate is determined by detecting in which divided section the change in electric current occurred. In the example of Figure 9, position resolution in X coordinate increases as total number (N) of divided sections 7_1 through 7_N of the opposing electro-conductive film 7 is increases. The size of each divided section along X axis is 63.5 to 254 μm, for example, and desirable range of N value is for example 240 to 480 in display dot quantity of such as PDA.

[0077] This invention shows significant effect by being applied for display devices having an active matrix substrate, however, this invention is not restricted within this. This invention may be applied for display devices with simple matrix drive, for example.

[0078] Figure 10 schematically shows constitution of a display device that functions by a simple matrix drive. This display device sandwiches a liquid crystal layer, that is not shown in the drawing, with the first substrate 91 which is applied with polarizer sheet / phase differential sheet 90 on its back, and the second substrate 95 which is applied with polarizer sheet / phase differential sheet 96 on its back.

[0079] On the liquid crystal side surface of the first substrate 91, stripe shape scanning electrodes 92 which extend in X axis direction are laid out. On the other hand, a color filter section 94 is formed on the liquid crystal side surface of the second substrate 95, and further on it, stripe shape scanning electrodes* 93 which extend in Y axis direction are laid out. The electrodes 92 and the electrodes 93 are in a relation of layout that they mutually cross, and orientation films are deposited on these electrodes which is not shown in the drawing.

Translator's note: This "scanning electrodes" shall be a mistake of "data electrodes".

[0080] In the display device of Figure 10, the scanning electrodes 92 or the data electrodes 93 are formed by pattering transparent electrodes. The scanning electrodes 92 or the data electrodes 93 also function as the electro-conductive film for position detection. The voltages that are applied on the scanning electrodes 92 or the data electrodes 93 are controlled by drive circuit / position detection circuit which are switched by a similar circuit with above described switching circuit.

[0081] Further, this invention is able to be applied for devices other than the liquid crystal display devices, organic EL devices, for example. Figure 11(a) and (b) show a constitution example of an organic EL device. In this display device, transparent electrodes 101, organic positive hole transportation layer 102, organic EL layer 103, and metal electrodes 104 are laminated in this order, on a glass substrate 100. Both transparent electrodes 101 and metal electrodes 104 are laid out in stripe shape, however, the transparent electrodes 101 and metal electrodes 104 are laid out to cross. The light that is generated in the organic EL layer is emitted toward downward through the glass substrate 100.

[0082] In this form of embodiment, contact with a finger or pen is done on back side of the glass substrate 100 (front side of the display device). And a transparent electrode that is divided in stripe shape, namely the transparent electrodes 101, is used as the electro-conductive film for position detection.

[0083] The voltage that is applied to the transparent electrodes 101 is controlled by drive circuit / position detection circuit which are switched with a similar circuit with above described switching circuit.

[0084]

[Effect of the invention] According to this invention, a transparent electro-conductive film, that is necessary for detecting the contact point by a pen or finger on a display surface with electrostatic capacitance

coupling method, is not separately added to a display device but an opposing electro-conductive film (transparent electro-conductive film) for display is utilized in time sharing, and detection of said contact point is done. Accordingly, it is able to avoid degradation of display quality that is caused when a separate transparent electro-conductive film is provided on front side of a display device.

[0085] In this invention, it is able to suppress delay of application of display voltage which may occur with the switching, because high speed switching is realized when the switching circuit, which is for high speed switching of the function of opposing electrode between display mode and position detection mode, is constituted using thin film transistors that are formed on the substrate, along with the display drive circuit and position detection circuit.

[0086] Further, by dividing the opposing electrode into multiple sections, detection of contact point in higher accuracy is enabled. In this case, there is a need to measure electric current running from each part of the transparent opposing electrode by contact to its surface with such as a finger, and mutual connecting wiring may formed to be simple and short by forming the drive circuit, position detection circuit and switching circuit on the same substrate, therefore, it does not cause delay of signal and production is also easy.

[Brief explanation of the drawings]

[Figure 1] An oblique view drawing of basic constitution in a form of embodiment of a display device according to this invention.

[Figure 2] A schematic for explaining operational principle (in the case of one dimensional) of a touch sensor in electrostatic capacitance coupling method.

[Figure 3] A plan view drawing showing layout of electrodes that are located at four corners of opposing electro-conductive film in a form of embodiment of this invention.

[Figure 4] A schematic for explaining operational principle (in the case of two dimensional) of a touch sensor in electrostatic capacitance coupling method.

[Figure 5] (a) is a plan view drawing showing an active matrix substrate that is used in the first form of embodiment of this invention, (b) is a schematic showing constitution of a switching circuit, and (c) is a wave graph showing change of voltage with time that is applied to an opposing electro-conductive film.

[Figure 6] A block diagram of a position detection circuit that is adopted in the form of embodiment of this invention.

[Figure 7] A plan view drawing showing a layout example of electrodes of an opposing electro-conductive film that is used in other form of embodiment of this invention.

[Figure 8] A plan view drawing showing other layout example of electrodes of said opposing electro-conductive film.

[Figure 9] A plan view drawing showing another composition of said opposing electrically conductive film.

[Figure 10] An oblique view drawing showing composition of a display device that operates with simple matrix drive.

[Figure 11] (a) is a cross sectional drawing showing basic composition of an organic EL display device, and (b) is its oblique view drawing.

[Explanation of numbers]

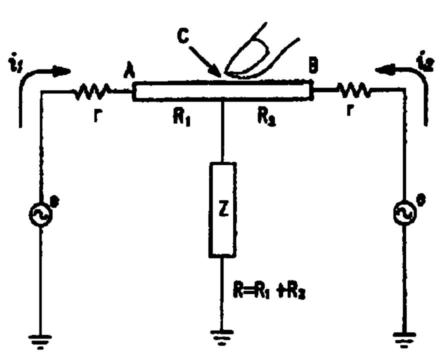
1: back light
2: diffuser sheet
3: first polarizer sheet
4: substrate
5: TFT array
6: liquid crystal
7: opposing electric conduction*

**Translator's note: This should be a mistake of "opposing electro-conductive film".*

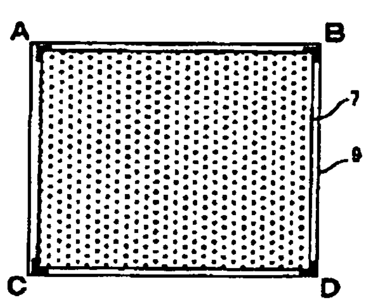
7_1 - 7_N: divided sections of opposing electro-conductive film
8: color filter
9: opposing substrate

10 second polarizer sheet
61: electric current change detection circuit
62: analog signal processing circuit
63: detection filtering circuit
64: noise removal DC conversion circuit
66: analog multiplexer
67: A/D converter
68: processing unit
90: polarizer sheet - phase differential sheet
91: first substrate
92: scanner electrode
93: data electrode
94: color filter section
95: second substrate
96: polarizer sheet - phase differential sheet
100: glass substrate
101: transparent electrode
102: organic positive hole transportation layer
103: organic EL layer
104: metal electrode
A-H: electrode being provided on opposing electrically conductive film
O_1 - O_{nx}:divided electrodes
P_1 - P_{nx}: divided electrodes
Q_1 - Q_{ny}:divided electrodes
S_1 - S_{ny}: divided electrodes

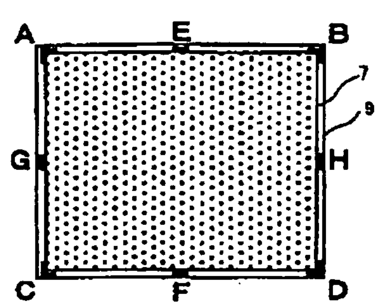
[Figure 2]



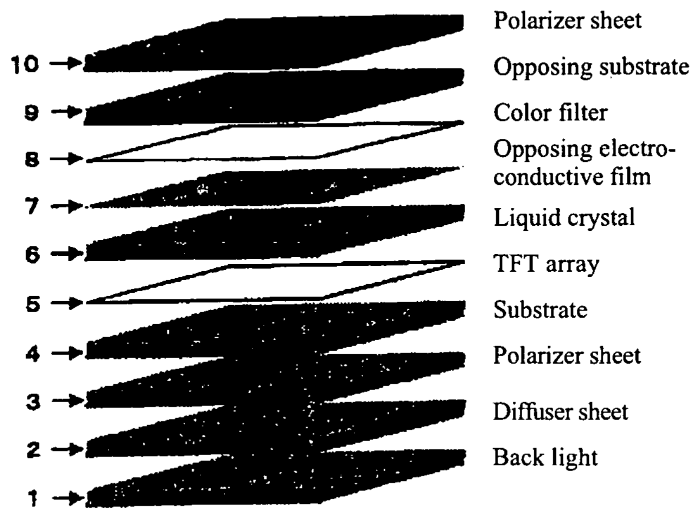
[Figure 3]



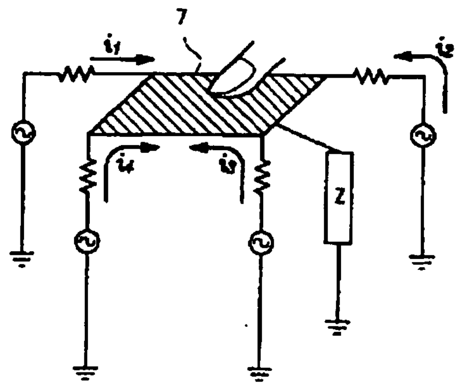
[Figure 7]



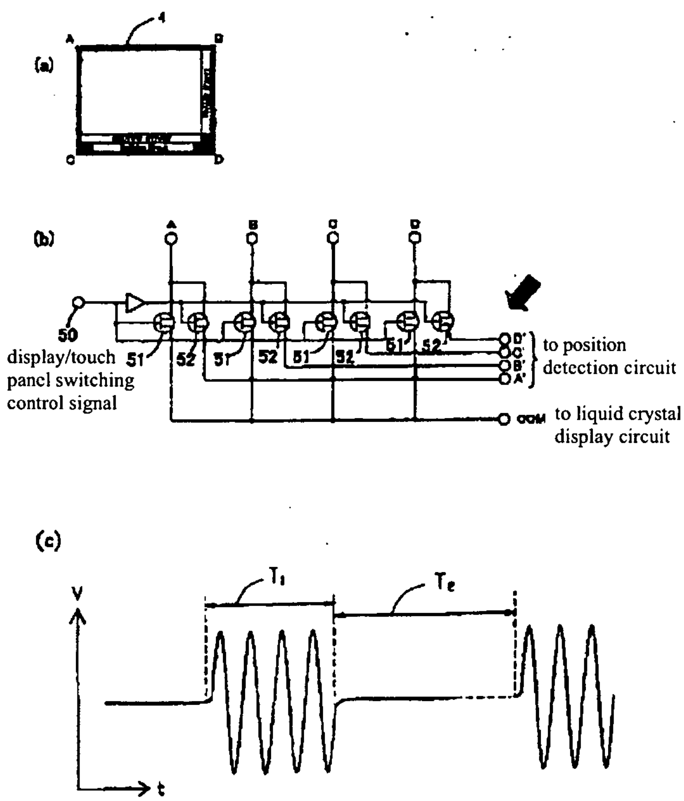
[Figure 1]



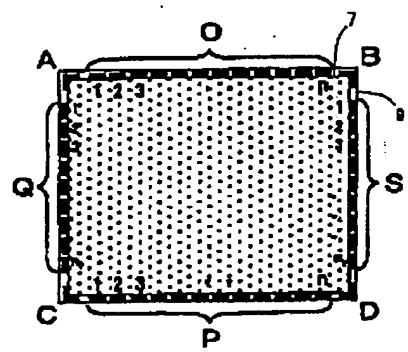
[Figure 4]



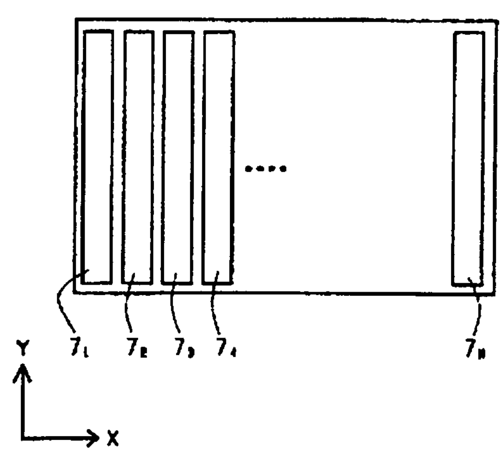
[Figure 5]



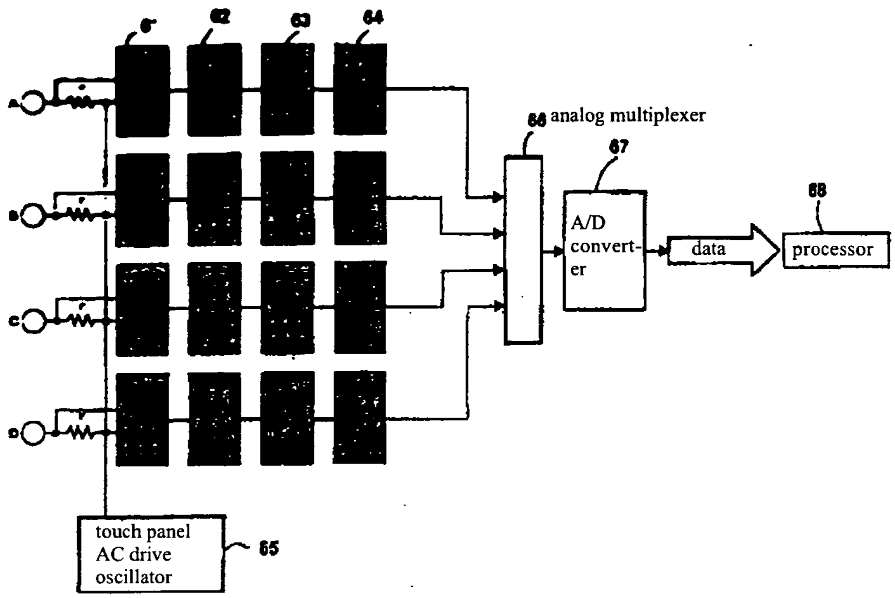
[Figure 8]



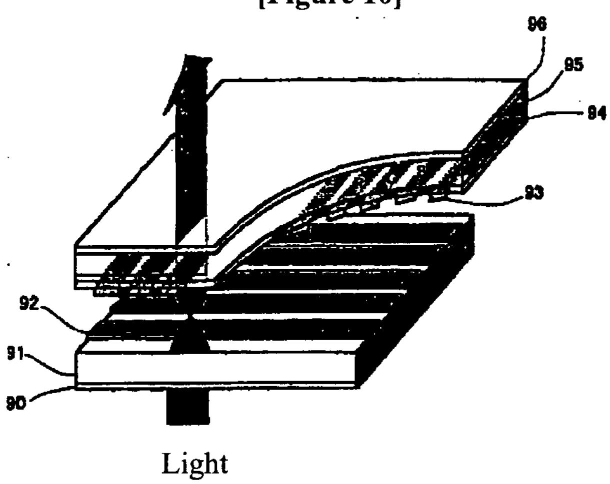
[Figure 9]



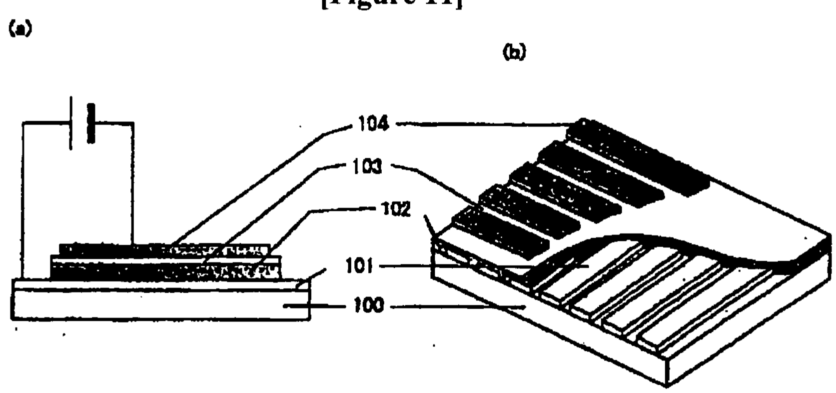
[Figure 6]



[Figure 10]



[Figure 11]



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F term (reference)	2H089	HA18	HA35	QA05	TA02	TA09
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